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Clean the Dirty Water Student Worksheet **Answer Key**

Phase 1: Introduction and Ask

Introduction Activity

You and your partner are walking down the street and come across a pond of dirty water sitting on the sidewalk after a day of rainstorms in your city.

1. What type of items/things would you see in the water to make it look dirty?

Answers may vary based on location and environment. Potential answers: grass, motor oil, human waste, sand.

2. How would you remove each item or thing in the water?

Answers may vary based on your location and environment. Example answers: something like tongs to remove leaves. A strainer to remove the sand and gravel.

The Engineering Design Challenge

You are a team of chemical and environmental engineers. Your mission is to design a filtration system to clean dirty water from a local water source in your city using inexpensive materials. The goal is to obtain approximately 10 mL of clean water.

Engineers use science to solve real-world problems like clean water access. Let's see how well your design works to clean the dirty water.

Qualitative and Quantitative Observations

Describe the sample using your qualitative observational skills. No tasting the sample!

Sight Answers will vary. Potential answer(s): brown, dirty.

Sound Answers will vary. Potential answer(s): swishy.

Smell Answers will vary. Potential answer(s): decaying.

Touch Answers will vary. Potential answer(s): cold, slimy.

Using a piece of pH paper, test the dirty water sample.

Color of pH paper Answers will vary based on the type of water, soil, sand, gravel used in the mixture.

pH value Answers will vary based on the type of water, soil, sand, gravel used in the mixture.

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Phase 2: Imagine and Plan Your Filtration System

Before putting a filtration system together, you must look at the available materials and imagine what you would use to create it. Below are the available materials to build your filtration system. Your group must use **THREE LAYERS**, with each layer a different material from the list of available materials. Remember, you will place your filtration system into a large plastic funnel to operate it. The goal is to obtain 10 mL of filtered water.

(Students will select three items on the list for their filter. These will vary from group to group.)

☐	Coffee filter	☐	Gauze
☐	Cotton fabric	☐	Baking soda
☐	Cotton balls	☐	Untreated sawdust
☐	Paper towels	☐	Grass clippings
☐	Felt		

- Thinking about the design of your filtration system, draw the system to show how you and your partner will layer the materials. In the drawing, identify each layer starting at the bottom to the top.

Designing and drawing the filtration system will vary from group to group. The drawing must have three layers of materials, with each layer of material identified for the water filtration system.

- What layers will you use in your filtration system starting from the bottom to the top?

Material Layer 3 (Top) Varies based on the choice of the group.

Material Layer 2 (Middle) Varies based on the choice of the group.

Material Layer 1 (Bottom) Varies based on the choice of the group.

- Why did you choose these layers for your filtration system?

Varies based on the choice of the group.

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Phase 3: Create Your Filtration System

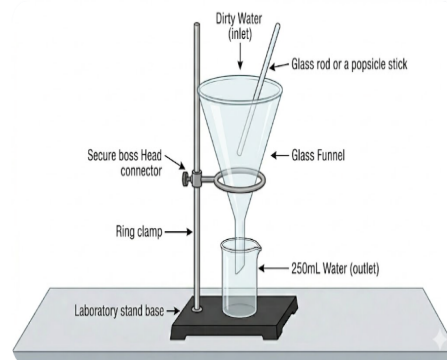
It is time to create your filtration system. You will need the following materials and equipment to set up your filtration system.

Materials

- 1 large plastic funnel
- 1 large 250 mL beaker
- 1 lab stand
- 1 ring support for the large plastic funnel
- chosen filtration materials

Instructions to set up filter and testing apparatus.

1. Assemble your selected filtration materials in the large plastic funnel, following the layer order you planned in Phase 2.
2. Attach the ring support to the lab stand.
3. Place the funnel containing your filtration system securely in the ring support.
4. Place the 250 mL beaker beneath the funnel to collect the filtered water. Adjust the height of the ring support, if necessary, so the funnel is positioned securely over the beaker.



Phase 4: Test Your Filtration System

It is time to put your filtration system to the test! You will need the following materials and equipment to test your filtration system.

Materials

- 1 sample of dirty water
- 1 piece of pH paper
- 1 large popsicle stick
- 1 50 mL graduated cylinder

Instructions to test your filter.

1. Review the pH of the dirty water that you recorded in Phase 1. Record this value in the data table below as your pH before filtration.
2. Before pouring, observe your dirty water sample. Remember that vegetable oil is less dense than water and may float on the surface. Gently stir the sample with the craft stick so the contents are distributed throughout the sample.
3. Slowly pour the dirty water into your filtration system.
4. Use the craft stick, if necessary, to transfer any soil, sand, or other material remaining in the sample container into the filter.
5. Observe your filtration system for approximately 10 minutes as the water passes through it. Pay attention to:

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- a. How quickly the water moves through the filter.
 - b. Where particles or oil appear to be trapped.
 - c. Any changes you notice in the filtration materials.
 - d. Any problems with the filtration system, such as clogging, leaking, or overflowing.
6. After filtration is complete, carefully remove the 250 mL collection beaker from beneath the funnel.
 7. Observe the filtered water. Record its color, clarity, visible particles, visible oil droplets or film, and any other relevant observations in the data table.
 8. Test the pH of the filtered water using pH paper. Record the pH in the data table.
 9. Pour the filtered water into the 50 mL graduated cylinder. Measure and record the volume of filtered water collected.

Qualitative and Quantitative Data

pH before filtering the dirty water	varies
pH after filtering the dirty water	varies
Amount of clean water obtained from the filtration system	varies

Describe the clean water after filtration using your qualitative data collection methods. No tasting the water!

Sight Varies based on the type of materials used in the filtration system.

Sound Varies based on the type of materials used in the filtration system.

Smell Varies based on the type of materials used in the filtration system.

Touch Varies based on the type of materials used in the filtration system.

Phase 5: Improve and Reflect Like an Engineer

Now that you have tested your filtration system, analyze your results and think like an engineer. What worked well? What could be improved? Use evidence from your observations and data to evaluate your design.

Evaluate Your Design

1. What role did each material play in your filtration system? What evidence from your test supports your answer?

Answers will vary based on the materials selected. Students should describe how each material may have affected the filtration process. For example, some materials may have trapped larger particles, captured smaller suspended particles, absorbed some liquid or oil, or affected the rate at which water moved through the filter.

2. Why did you and your partner choose these materials and arrange them in this order?

Answers will vary. Students should connect their choices to the properties of the materials and their predictions about how each layer would affect the dirty water.

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3. How much filtered water did your filtration system produce? Did you meet the goal of approximately 10 mL?

Answers will vary based on the filtration system. Students should use the volume recorded in Phase 4 as evidence.

4. Compare your filtered water with the original dirty water. How effectively did your filtration system improve the water?

Answers will vary. Students should support their conclusions using their before- and after-filtration observations and pH measurements.

Compare Designs

1. Compare your filtration system and results with those of another group.

- a. What did the other group(s) do differently than your group?

Answers will vary. Students may identify differences in filtration materials, number of layers, layer order, or other aspects of the design.

- b. How did the other group's results compare with your results?

Answers will vary. Students should compare evidence such as clarity, visible particles or oil, pH, and volume of filtered water collected.

- c. What can you learn from the other group's design and results?

Answers will vary. Students should identify design choices that appeared to improve or reduce filtration performance.

Improve Your Design

Connect to Real-World Engineering

2. Why is it important to create a water filtration system to clean the water you drink from your faucet at home?

Answers will vary. A sample response is below for guidance.

Creating a home water filtration system is important because municipal water can pick up dangerous contaminants like lead from old pipes, microplastics, and chemical residues (like chlorine and PFAS) on its journey to your faucet. Filtering water at home removes these health hazards, improves the taste and smell, and provides an eco-friendly alternative to plastic bottled water.

3. Why do you think chemical and environmental engineers are important in real life?

Answers will vary. A sample response is below for guidance.

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Chemical engineers are essential because they take laboratory-scale scientific discoveries and turn them into mass-produced, real-world solutions. They are responsible for mass-producing lifesaving medicines, developing clean energy alternatives like electric vehicle batteries, scaling up food production through fertilizers, and designing systems to clean our environment.

Environmental engineers are vital because they protect human health and the planet simultaneously. They are the ones who ensure we have safe drinking water, design systems to trap industrial air pollution, build eco-friendly landfills that will not poison our groundwater, and use biotechnology to clean up toxic oil spills and hazardous waste sites. Without them, modern cities would quickly become unlivable due to pollution and disease.

Extension

Using your student-issued laptop or personal device, research the following questions to make connections to the creation of your water filtration system.

1. How does this activity relate to real water treatment plants?

Answers will vary. A sample response is below for guidance.

This activity is a mini version of what happens at a real city water treatment plant. When we pour water through layers like gravel, sand, and charcoal, we are doing the exact same thing real plants do on a massive scale to trap dirt, rocks, and rust. The charcoal layer is especially cool because it acts like a magnet, soaking up bad smells, weird tastes, and invisible chemicals. The main difference is that a real water plant takes things a step further. They add safe chemicals to make tiny dirt particles stick together so they are easier to catch, and they use stuff like chlorine or UV light to kill microscopic germs and bacteria that a regular filter can't trap.

2. What are other examples where chemical and environment engineers solving global problems?
- Answers will vary. A sample response is below for guidance.

Chemical and environmental engineers work together like a team to fix some of the biggest problems on Earth, especially when it comes to saving the planet. To fight climate change, chemical engineers build better, longer-lasting batteries for electric cars, while environmental engineers build giant "smoke-scrubbers" used by factories to trap greenhouse gases before they can escape into the air. Also, they are teaming up to fight plastic pollution by inventing new plastics made from plants that can naturally break down and building smart recycling centers to reuse old trash. Finally, they help feed the world by creating safer fertilizers for farming while making sure those chemicals do not wash into local rivers and hurt wild animals.

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